CLAIMS

WE CLAIM:

1. A respiration monitor comprising:

a spirometer adapted to receive air flow from a patient's lungs with breathing to provide an air flow signal;

a chest displacement sensor adapted to monitor displacement of the patient's chest with breathing to provide a chest displacement signal; and

a calibration circuit receiving the air flow signal and the chest displacement signal to provide a corrected respiration signal combining information from both the air flow signal and the chest displacement signal.

2. The respiration monitor of claim 1 wherein the calibration circuit includes:

an integrator receiving the air flow signal to produce a lung volume signal; and

a baseline corrector receiving the lung volume signal and the chest displacement signal to correct an integration offset of the lung volume signal to produce the corrected respiration signal based on the chest displacement signal.

3. The respiration monitor of claim 2 wherein the correction of integration offset occurs periodically at a predetermined phase of respiration by setting the lung volume signal equal to a stored calibration value.

4. The respiration monitor of claim 3 wherein the calibration value is a previous value of the lung volume signal at the predetermined phase.

5. The respiration monitor of claim 1 wherein the calibration circuit includes:

an integrator receiving the air flow signal to produce a lung volume signal; and

a model of the relationship between lung volume and chest displacement signal, the model receiving the chest displacement signal to provide a lung volume signal as the corrected respiration signal.

6. The respiration monitor of claim 5 wherein the model is a linear function relating chest displacement signal to lung volume.

7. The respiration monitor of claim 6 wherein the model is a multiplier multiplying the chest displacement signal by a factor determined from a correlation between the lung volume signal and the chest displacement signal to produce the corrected respiration signal.

8. The respiration monitor of claim 5 wherein the model is a non-linear function relating chest displacement signal to lung volume.

9. The respiration monitor of claim 8 wherein the model is a lookup table recording a relationship between lung volume and chest displacement for at least one cycle of breathing, the lookup table receiving chest displacement signal to output the corrected respiration signal.

10. The respiration monitor of claim 5 wherein the model provides a different functional relationship between chest displacement signal and lung volume during inspiration and exhalation.

11. The respiration monitor of claim 5 wherein the model detects a breath-hold from the chest displacement signal and holds the corrected respiration signal constant until an end of the breath-hold.

12. A radiation therapy system comprising:

a respiration monitor providing:

(i) a spirometer adapted to receive air flow from a patient's lungs with breathing to provide an air flow signal;

(ii) a laser displacement sensor adapted to monitor displacement of the patient's chest with breathing to provide a chest displacement signal; and

(iii) a calibration circuit receiving the air flow signal and the chest displacement signal to provide a corrected respiration signal combining information from both the air flow signal and the chest displacement signal;

a controllable radiation source receiving the corrected respiration signal to control radiation delivered to a patient according to the respiration signal.

13. A medical imaging system comprising:

a respiration monitor providing:

(i) a spirometer adapted to receive air flow from a patient's lungs with breathing to provide an air flow signal;

(ii) a laser displacement sensor adapted to monitor displacement of the patient's chest with breathing to provide a chest displacement signal; and

(iii) a calibration circuit receiving the air flow signal and the chest displacement signal to provide a corrected respiration signal combining information from both the air flow signal and the chest displacement signal;

an imager receiving the corrected respiration signal and acquiring component image signals from a patient over different phases of respiration, and mathematically combining the component image signals according to phases of respiration when the component image signals were acquired to produce a composite image.

14. The respiration monitor of claim 1 further including a patient display displaying the corrected respiration signal to the patient.

15. A method of generating a corrected respiration signal comprising the steps of:

(a) monitoring a patient's breathing with a spirometer adapted to receive air flow from a patient's lungs to provide an air flow signal;

(b) monitoring the patient's breathing with a chest displacement sensor adapted to monitor displacement of the patient's chest with breathing to provide a chest displacement signal; and

(c) combining the air flow signal and the chest displacement signal to provide a corrected respiration signal.

16. The method of claim 15 including the steps of:

integrating the air flow signal to produce a lung volume signal; and

using the chest displacement signal to correct an integration offset of the lung volume signal to produce the corrected respiration signal.

17. The method of claim 16 wherein the correction of integration offset occurs periodically at a predetermined phase of respiration by setting the lung volume signal equal to a stored calibration value.

18. The method of claim 17 wherein the stored calibration value is a previous value of the lung volume signal at the predetermined phase.

19. The method of claim 15 including the steps of:

integrating the air flow signal to produce a lung volume signal; and

applying the lung volume signal to a model of the relationship between the lung volume and chest displacement signals to provide a lung volume signal as the corrected respiration signal.

20. The method of claim 19 wherein the model is a linear function relating chest displacement signal to lung volume.

21. The method of claim 20 wherein the model is a multiplier multiplying the chest displacement signal by a factor determined from a correlation between the lung volume signal and the chest displacement signal to produce the corrected respiration signal.

22. The method of claim 19 wherein the model is a non-linear function relating chest displacement signal to lung volume.

23. The method of claim 22 wherein the model is a lookup table recording a relationship between lung volume and chest displacement for at least one cycle of breathing, the lookup table receiving chest displacement signal to output the corrected respiration signal.

24. The method of claim 15 wherein the model provides a different functional relationship between chest displacement signal and lung volume during inspiration and exhalation.

25. The method of claim 15 wherein the model detects a breath-hold from the chest displacement signal and holds the corrected respiration signal constant until an end of the breath-hold.

26. A method of radiation therapy system comprising the steps of:

(a) monitoring a patient's breathing with a spirometer adapted to receive air flow from a patient's lungs to provide an air flow signal;

(b) monitoring the patient's breathing with a chest displacement sensor adapted to monitor displacement of the patient's chest with breathing to provide a chest displacement signal;

(c) combining the air flow signal and the chest displacement signal to provide a corrected respiration signal; and

(d) controlling radiation delivered to a patient according to the respiration signal.

27. A method of medical imaging comprising the steps of:

(a) monitoring a patient's breathing with a spirometer adapted to receive air flow from a patient's lungs to provide an air flow signal;

(b) monitoring the patient's breathing with a chest displacement sensor adapted to monitor displacement of the patient's chest with breathing to provide a chest displacement signal; and

(c) combining the air flow signal and the chest displacement signal to provide a corrected respiration signal;

(d) acquiring component image signals from a patient over different phases of respiration; and

(e) mathematically combining the component image signals according to phases of respiration when the component image signals were acquired to produce a composite image.